

# Recollections of 1960 Investigation of Yugoslavian Reactor Accident

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The personnel exposed to ionizing radiation during the reactor accident at the Institute Boris Kidric at Vinca, Yugoslavia were taken to Paris for medical treatment. Several of them received bone marrow transplants. Because this was a new treatment there was a lot of interest in determining the doses received by each individual. In order to determine those doses, an investigation was sponsored and coordinated by the International Atomic Energy Agency (IAEA).

Participants in the investigation included personnel from IAEA, a French team who built a new control system and operated the reactor from a remote location, a British team who supplied the needed heavy water, an American team who did dosimetry and the hosts, the Yugoslavians, who supplied the facilities, the reactor and the knowledge of the accident. All of the participants worked well together although there was no common language that everyone spoke. People learned to communicate using a few understood words and a lot of gestures.

The basic idea of the investigation was to operate the reactor and measure neutron and gamma dose rates, neutron to gamma ratios, neutron spectrum and Na-24 production in human-like, sodium chloride solution filled phantoms. By determining the conversion of Na-23 to Na-24 as a function of neutron dose, applying the proper neutron to gamma dose ratio and normalizing to the amount of Na-24 measured in the exposed personnel by French doctors a total dose could be calculated for each exposed person. Technical aspects of the investigation have been covered thoroughly in publications so the intent of this narrative is to tell some of the sidelights of doing an international operation.

As the most junior member of the American dosimetry team from the Oak Ridge National Laboratory, I was responsible for the phantoms. The use of phantoms with a homogeneous filling of aqueous sodium chloride solution to represent a heterogeneous human had just been verified using a burro and burro phantom at the Los Alamos Godiva reactor. (Health physics, 1962, Vol.8 pp. 371-379.)

In preparing for the investigation a question arose about the availability of chemically pure sodium chloride and water with no impurities which could be activated by neutrons and would complicate Na-24 counting. We asked to have a sample of the available CP sodium chloride and local water sent to Oak Ridge for evaluation. The samples did not arrive so a decision was made to take along a case of CP sodium chloride and to use local water. Long after the team had returned home, after the investigation, a package covered with hazardous material warning labels arrived. It contained two bottles of CP "Natrium Chloritum" (different brands) and two bottles containing water and labeled "Biz Deturzent". The package had been held up in US Customs because "natrium chloritum" isn't listed in the handbook of hazardous materials, so it must be exotic bad stuff.

One detail of preparation that took some procurement research involved electrical power. Yugoslavian power, like much of continental Europe, is 50 cycle, 230 volt. Our counting equipment was 60 cycle, 115 volt. Therefore converters had to be procured and shipped.

At the time of the investigation, Oak Ridge National Laboratory supplied tan shirts and pants for staff members who were doing dirty physical (but not radioactively contaminated) work. We took those work clothes along because we had to move equipment, stack lead bricks, mix sodium chloride solutions, etc. Unfortunately some of the personnel at the Boris Kidric Institute, who were not involved and did not know about the investigation, thought that we were Germans, who were disliked at that time. This caused a small public relations problem. To minimize contacts we decided to take our lunch rather than eat at the canteen. We bought two loaves of delicious heavy bread, some cheese, some sausage and two large bottles of beer. We had just finished lunch when the Director of the Institute walked in and looked around at the remains of our lunch. He picked up one of the empty bottles and said, "I do not approve of this!" We thought that we had goofed. Then the Director grinned and said "You did not leave any for me,"

One thing that has changed greatly is the transportation of radioactive materials. The neutron spectrum was to be measured using threshold detectors consisting of gold and cadmium covered gold foils, fission foils of plutonium-239, neptunium-237, uranium-238 and sulfur pellets. The plutonium, neptunium and uranium foils were, of course, sealed sources. We put the fission foils in a small lead pig and put the whole lot in an airline flight bag and climbed onto an airplane. Four of us traveling together took turns keeping the flight bag between our feet. After leaving New York we landed at London, Frankfurt and Vienna. Each time we landed someone from the American embassy would check on us and ask "How is the plutonium?" The last leg of the journey to Belgrade was by train. The fission foils were then locked in an embassy safe until used,

At the end of each day in which the reactor had been operated Paul Reinhardt, who analyzed the threshold detectors, had to spend some time in the count room which we had set up in the basement of another building. We shared a counter, so after he was finished I counted the 44 Na-24 samples which I had taken from all of the compartments of the four phantoms. The other team members waited somewhat patiently for U.S.

"Somewhat" was because the next phase of the investigation started each day after work. That phase was "Hospitality". The French and American teams gave cocktail parties and the Institute and the Yugoslav Nuclear Energy Commission gave dinner parties. Even though there were language difficulties, these parties really enhanced the feelings of teamwork and international cooperation. The French and American teams were not good at other languages but the Yugoslavs were great linguists. In addition to the parties several of the Yugoslavs took pairs of the visitors out to dinner and for sight seeing tours. They were all most generous and hospitable.

At the conclusion of **the** operation a group **of** our Yugoslavian hosts took the American team to **the airport**. **While** one of them took our **passports through customs the others** took us into the bar **where** we toasted the operation with **Slivovitz**, the potent plum brandy.

**The** return trip **was** something different **from** present **practice**, too. At that time the US **Atomic Energy** Commission flew **its** employees and contractors first class. **We** had to share moms, though. Somehow **our team leader** convinced the people who approved travel that for the **cost** of **first class airfare** we **could come** back by ship **in** "Cabin Claw" (second class). The Atlantic crossing would take five days which **would allow** us to recuperate from the **rigors** of the investigation and allow **some time** for data **reduction**. We did work about 4 **hours per day on data**. **In those days a 4** function calculator was strictly mechanical, the size **of a** typewriter, and **cost a month's salary** for **a** young Health Physicist. **So we** did addition **and subtraction by hand and used slide** rules **for** multiplying, dividing and **exponentials**. We carried a long slide rule, about 2 feet **long**, which **allowed accuracy to 4 significant** figures. (**For** those who don't remember, or have never **used**, slide rules. the order of **magnitude** had to be **calculated** by hand. This **gave** a reality check and made sure that **we did not move a** decimal point in the wrong direction.)

**Overall** the reactor **accident** investigation was a wonderful **introduction** to international cooperation and **travel** for several young health physicists.